Exhaustive Variation

Diesel Studies Should Look at Particle Differences

In the past 12–15 years, most experiments on the health effects of diesel exhaust particles (DEP) have employed samples from one of two types of engines. Automobile-generated DEP has been tested extensively for its effects on the heart and lungs, but not its mutagenic properties. Forklift-generated DEP, on the other hand, has been tested primarily for genotoxicity but not for heart effects, and has been used in only limited studies of lung effects. In two companion papers published this month, Pramila Singh and David M. DeMarini of the U.S. Environmental Protection Agency and their colleagues report the findings of the first head-to-head testing of these two types of DEP samples [***EHP*** **112:814–819, 820–825**]. The results confirm that DEP can be highly variable and that future DEP health effects research would benefit from a fuller characterization of a wide variety of samples beyond the two standard samples used by researchers for more than a decade.

The researchers performed comparative physical and chemical analyses of a standard sample of automobile- and forklift-generated DEP and found that both samples had a pH of 3.3. But almost every other physical and chemical trait was markedly different. For instance, the automobile DEP had 10 times the organic carbon and about 13 times the extractable organic material of the forklift DEP, but less than one-sixth the elemental carbon. The automobile DEP had more polycyclic aromatic hydrocarbons per mass of particle than the forklift DEP, and a much higher proportion of aliphatic hydrocarbons and alkanes. The forklift DEP had a much greater range of particle sizes and a finer, more porous surface texture. This diversity in traits likely arises from differences in DEP collection methods and from the contrasting designs of the different engines.

The researchers also compared the pulmonary effects of the two DEP samples in mice, and their genotoxic effects in six strains of *Salmonella*. Both samples created similar levels of pulmonary injury but distinctly different cellular inflammatory responses; the authors suggest that the distinctive physical and chemical properties of the samples may have contributed to this difference in the mechanism of action. In the *Salmonella* experiments, the automobile DEP tended to be much more mutagenic than the forklift DEP in most, but not all, conditions.

Diesel diversity. Variation in the sources, sampling, and study of diesel particles makes developing diesel exhaust standards difficult.

The researchers did not draw any specific conclusions regarding human health impacts of either type of DEP, because the exposure techniques used do not reflect real-world experiences. Instead, the studies simply revealed differences and similarities between the two DEP samples.

The researchers conclude that an increased understanding of the health effects of DEP will require evaluation of a wide range of DEP samples produced by different engines and fuels under different operating parameters. As more studies find evidence of potential health risks from diesel exposures such as riding in diesel school buses and living near freeways, the authors write, DEP health effects research must become multidisciplinary, involving chemists, engineers, biologists, and modelers. **–Bob Weinhold**

Disinfection Question

How Should We Measure Exposure?

Chlorination of public water supplies began in the early 1900s and quickly led to a massive reduction in waterborne diseases. At the same time, chlorination and other disinfection methods introduced a subtler threat to public health: disinfection by-products (DBPs), chemicals formed when disinfectants react with organic or inorganic matter in the water. Several DBPs cause carcinogenic, mutagenic, reproductive, or developmental effects, and many DBP studies have focused on effects of exposure *in utero*. Traditionally, total trihalomethane (THM) exposure is used as a surrogate in epidemiological studies to estimate maternal DBP exposure during pregnancy, partly because of data availability (THMs have been measured since the late 1970s) and partly because THMs are so prevalent. However, research led by J. Michael Wright of the U.S. Environmental Protection Agency's National Center for Environmental Assessment suggests that estimating DBP exposure from total THM concentrations alone provides insufficient information about risks to public health [***EHP*** **112:920–925**].

Wright and his colleagues focused on potential DBP-associated developmental effects, using specific end points including birth weight among full-term newborns (born at 37–45 weeks of pregnancy), birth before 37 weeks (preterm delivery), and pregnancy duration (gestational age). Birth weight and gestational age were further used to identify small-for-gestational-age (SGA) infants, defined as being in the 10th percentile for birth weight given gestational age. Preterm delivery and low birth weight are strongly associated with significant infant health problems—U.S. infant mortality is largely attributable to preterm delivery.

Birth certificates from Massachusetts towns with 10,000 or more residents provided Wright's group with information on 196,000 infants born during 1995–1998 and their mothers. This information was matched with exposure data for three types of DBPs: THMs, haloacetic acids, and MX. The team estimated the mother's average third-trimester exposure to THMs and haloacetic acids based on each town's water supply monitoring data. Data for MX came from earlier studies by Wright and colleagues, in which they had measured drinking water concentrations of MX and mutagenic activity (as measured by the Ames test). For each DBP, the researchers categorized exposure as low, intermediate, or high.

Of the 196,000 births, 6% were preterm, and 9% of full-term infants were SGA. Intermediate to high total THM exposure was linked to a small but statistically significant 12- to 18-gram reduction in birth weight. High exposure to MX and to mutagenic activity was also related to birth weight reduction, with mutagenic activity associated with the largest reduction (27 grams). Intermediate to high exposure to either THMs or mutagenic activity was associated with an increased risk of being SGA.

The clinical significance of the small changes observed is unknown, but it could potentially have a large public health impact, given the extent of DBP exposure. The researchers note that the associations seen between mutagenic activity and mean birth weight are unlikely to be due to THMs or haloacetic acids, because these chemicals are not considered strong mutagens. Even MX, a potent mutagen, did not appear to substantially affect the association between mutagenic activity and mean birth weight. The researchers suggest that mutagenic activity may eventually prove to be a better indicator of exposure to the complex mixtures of DBPs than measurement of traditional DBP surrogates, but more research is needed to determine the relationship between mutagenicity and individual DBPs. **–Julia R. Barrett**

Risky Shellfish?

Assessing Hazards of Clam Consumption

Although the north shore of the St. Lawrence River's lower estuary is regularly inspected for the presence of toxic algae and biological contamination, this coastal ecosystem is not regularly monitored for chemical contaminants. Bioaccumulation of such contaminants does not significantly harm shellfish, so they remain viable for harvesting. Yet chemical contaminants concentrated in their meat may pose a threat to human consumers. A study of Canadian recreational fishermen who harvest soft-shell clams in the St. Lawrence estuary now suggests that eating as few as 15 meals per year of these shellfish may represent a risk of cancer to consumers that exceeds cutoffs used in various U.S. Environmental Protection Agency (EPA) programs such as setting of fish consumption advisories [*EHP* **112:883–888**]. The study is the first to document the consumption habits of recreational harvesters in this area while simultaneously characterizing the nature and degree of chemical contaminants present in the area.

Fabien Gagnon and colleagues from Québec's Direction de Santé Publique de la Côte-Nord and Laval University interviewed 162 harvesters at 18 popular shellfish-collecting sites about the number of shellfish meals they had eaten in the last week and the last year. Harvesters were also asked to keep a food diary over the next 30 days recording the amount and type of shellfish they consumed and the location of harvest. This information and other published data formed the basis for four consumption scenarios.

The researchers sampled soft-shell clams at eight locations that were close to sources of point and nonpoint chemical pollution, for laboratory analysis. They focused their study on soft-shell clams because these were the primary shellfish that the fishermen ate. They tested for 56 potentially harmful chemicals that are known to bioaccumulate in clams and whose presence is relatively constant in the environment, including 10 metals, 22 polycyclic aromatic hydrocarbons, 14 polychlorinated biphenyls (PCBs), and 10 chlorinated pesticides.

Thirty-six of the chemicals were found in at least one shellfish sample; 25 were detected in at least 70% of the samples. To estimate the daily intake of contaminants, the researchers applied a mathematical formula factoring in the contaminant concentration, the four different consumption scenarios, and the average weight of a Canadian adult (70 kilograms) to determine a dose expressed as micrograms per kilogram per day. They evaluated both cancer and noncancer health risks.

PCBs and inorganic arsenic were the only chemicals found at concentrations that exceeded cancer risk thresholds. The researchers assessed cancer risks for the detected concentrations of PCBs and inorganic arsenic based on the dose–response relationship established by the EPA for these two contaminants. Even for the lowest clam consumption scenario (6.2 kilograms per year, or about 15 meals), risk assessments were greater than the level of 1×10^{-6} for lifetime exposure to PCBs and the level of 1×10^{-5} for lifetime exposure to inorganic arsenic; long-term exposure to such levels of these substances would lead to more than 1 case of cancer per 100,000 persons exposed.

Assessment of noncancer risks—which included skin reactions, diabetes mellitus, high blood pressure, and kidney disease—relied on exposure limit recommendations proposed by many agencies, including the EPA. The team found no significant risk of noncancer health effects to consumers based on their consumption scenarios of soft-shell clams from the study area. However, the authors recommend that other factors be considered before ruling out threats in that risk category. For example, not all harvesting areas were sampled, and the sample size was small for each study area. Also, the highest estimated exposures for contaminants such as inorganic arsenic, cadmium, and chromium were very close to the conservative exposure limits set by the EPA and other agencies. Furthermore, some scientists believe the acceptable thresholds set by regulatory and advisory agencies may be too liberal. Finally, risks to children may be greater because they ingest larger amounts of food in proportion to their body weight.

The authors recommend the implementation of a program for monitoring the chemical contamination present in areas of the St. Lawrence River estuary where shellfish are harvested. Such a program could provide data on which a shellfish consumption guide could be based. **–Carla Burgess**

Bryan Allen/Alamy

Questions about clams. A study of 56 contaminants known to bioaccumulate in soft-shell clams suggests that some levels may be dangerously high, and more monitoring is necessary.